AD-A179 331 A PROGRAM OF GROUND-BASED ASTRONOMY TO COMPLEMENT EINSTEIN OBSERVATIONS(U) COLUMBIA UNIV NEW YORK COLUMBIA ASTROPHYSICS LAB D J HELFAND DEC 86 CAL-1629 1/1

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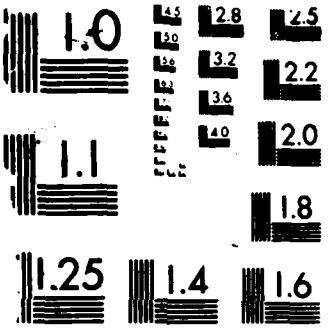

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TITLE OF RESEARCH:

A Program of Ground-Based Astronomy to Complement *Einstein* Observations

PERIOD OF RESEARCH:

October 1, 1981 - September 30, 1986

PREPARED BY:

Columbia Astrophysics Laboratory
Departments of Astronomy and Physics
Columbia University
538 West 120th Street
New York, New York 10027

PRINCIPAL INVESTIGATOR:

David J. Helfand
Associate Professor of Physics

DECEMBER 1986

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Our program of multiwavelength observational investigations and their attendant interpretive studies concerning problems in stellar coronae, supernova remnants, and neutron star astrophysics continued in FY 86. A variety of important projects have been undertaken, several of which reached completion in the last year of the five-year period (1 October 1981 to 30 September 1986), including the compilation of the complete X-ray flux-limited sample of M stars, a study of small scale anisotropy of the extragalactic X-ray background, and a definitive paper on the new class of composite SNRs. A total of 26 papers presenting the results of the program were published or accepted for publication in the –

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Figure 8. Report Documentation Page, DD Form 1473 (1 of 2)

technical literature, as well as six review articles for conference proceedings. A total of 35 presentations were given at regional, national, and international meetings by the principal investigator, two co-investigators, and/or the six graduate students supported under this program. In addition, radio and optical observations under several existing proposals were conducted and more than twenty new proposals were prepared, the majority of which have already been accepted.

Figure 8. Report Documentation Page, DD Form 1473 (2 of 2)

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C. RESEARCH OBJECTIVES

During the five-year period 1 October 1981 through 30 September 1986, the Columbia Astrophysics Laboratory, with the support of the AFOSR, has been engaged in a program of ground-based astronomy to complement observations made in the X-ray spectral regime with the Einstein Observatory. A broad range of topics of current astrophysical interest has been pursued, including multispectral observations of active galactic nuclei, numerous studies of supernova remnants and the neutron stars they are thought to contain, investigation of processes leading to high energy emission in the winds and coronae of stars, and fundamental new work on the nature and origin of both the galactic and extragalactic components of the diffuse X-ray background. Observations have been obtained in the radio, optical and infrared regimes as a result of our 50 requests for observing time supported by this grant. A total of 26 papers have appeared or been accepted for publication in refereed journals and six review articles for conference proceedings have been published. In addition, the results of this research have been presented in 35 talks at regional, national, and international meetings. And, perhaps most importantly, five PhDs have been or soon will be awarded to U.S. graduate students who have been supported in whole or in part by this grant.

The last year of this grant has seen the completion of many of the important projects we have undertaken over the past few years. Highlights include the publication of the complete X-ray flux-limited sample of M stars and the determination that the contribution of all stars to the galactic soft X-ray background is small (<10%); the acceptance for publication of our study of the small scale anisotropy of the extragalactic X-ray background and its conclusion that the integrated emission from quasars does <u>not</u> (as previously

believed) explain that background; and the acceptance for publication of a definitive paper of the new class of composite supernova remnants, most of which were discovered as a result of VLA observations supported as part of the program. Several other projects are nearing completion but must be eventually published when another source of support has been identified. These include the discovery of a millisecond pulsar condidate in a globular cluster and the massive Orion survey of X-ray emission from young stars throughout the H-R diagram, along with the definitive study of the diffuse X-ray emission from the Large Magellanic Cloud and the search for radio supernova remnants in members of the Local Group. Finally, a major new project which was conceived as a result of work performed under the grant--the construction of uniquely sensitive and detailed map of a large portion of the Galactic plane at 327 MHz--has been accepted for a pilot study at the Very Large Array and has formed the basis for a recent proposal to another Federal agency.

Over 176 pages of scientific results have been prepared and published under the support of this grant, and it would be redundant to detail those results here. We list in the following sections all refereed papers (§ II), review articles (§ III), and presentations (§ IV) produced by the researchers and students (§ V) who have worked under this grant. As Appendix A, we include reprints and preprints of refereed articles as a convenience for the interested reader.

D. PUBLICATION LIST

Contributions Submitted to Refereed Journals

Gary A. Chanan, Bruce Margon, David J. Helfand, Ronald A. Downes, and Don R. Chance, "Two X-ray Selected BL Lacertae-Type Objects," *Astrophys. J. (Letters)* **261**, L31 (1982).

Richard L. White and R.H. Becker, "The Resolution of P Cygni's Stellar Wind," *Astrophys. J.* **262**, 657 (1982).

R.H. Becker and D.J. Helfand, "High Resolution X-ray and Radio Maps of the Millisecond Pulsar," *Nature* **302**, 688 (1983).

R.H. Becker, David J. Helfand, and A.E. Szymkowiak, "G29.7-0.3: Another Supernova Remnant with an Identity Crisis," *Astrophys. J. (Letters)* **268**, L93 (1983).

Andrew Cheng and David J. Helfand, "X-rays from Radio Pulsars: The Detection of PSR 1055-52," *Astrophys. J.* **271**, 271 (1983).

D.J. Helfand, M.A. Ruderman, and J. Shaham, "X-ray Emission and Spin-Up Evolution of the Binary 6.1 ms Pulsar," *Nature* **304**, 423 (1983).

D.J. Helfand and R.H. Becker, "The Observation of Stellar Remnants from Recent SNR," *Nature* **307**, 215 (1984).

G.A. Chanan, D.J. Helfand, and S.P. Reynolds, "An Optical Synchrotron Nebula Around the X-ray Pulsar 0540-693 in the Large Magellanic Cloud," *Astrophys. J. (Letters)* **287**, L23 (1984).

D.J. Helfand, D. Chance, R. Becker, and R.L. White "VLA Observations of Compact Radio Sources in the Galactic Plane: A Search for Crab-like Supernova Remnants" *Astron. J.* **89**, 819 (1984).

R.H. Becker and D.J. Helfand "New Radio Observations of the Composite SNR G29.7-0.3" *Astrophys. J.* **283**, 154 (1984).

John P. Hughes, David J. Helfand, and Steven M. Kahn "Interpretation of the Number vs. Diameter Distribution for Supernova Remnants in the LMC" *Astrophys. J. (Letters)* **281**, L25 (1984).

David J. Helfand "Endpoints of Stellar Evolution: X-ray Surveys of the Local Group" *PASP* **96**, 913 (1984).

D.J. Helfand and R.H. Becker "Origin of the New Axisymetric Radio Sources" *Nature* **313**, 118 (1985).

R.H. Becker and D.J. Helfand "A New Class of Nonthermal Radio Sources" *Nature* **313**, 115 (1985).

G.A. Kriss, R.H. Becker, D.J. Helfand, and C.R. Canizares, "G27.4+0.0 A Galactic SNR with a Central Compact Source" *Astrophys. J.* **288**, 703 (1985).

Jean-Pierre Caillault, Gary A. Chanan, David J. Helfand, Joseph Patterson, John A. Nousek, Leo Takalo, Gregory Bothun, and Robert Becker "The Peculiar X-ray and Radio Source AS431" *Nature* **313**, 376 (1985).

T.T. Hamilton, D.J. Helfand, and R.H. Becker, "A Search for Millisecond Pulsars in Globular Clusters" *Astron. J.* **90** 606 (1985).

Jean-Pierre Caillault and David J. Helfand "The *Einstein* Soft X-ray Survey of the Pleiades" *Astrophys. J.* **289**, 279 (1985).

R.H. Becker and D.J. Helfand "Identification of G20.0-0.2 as a Crab-Like Supernova Remnant" *Astrophys. J.* **297**, L25 (1985).

John P. Hughes and David J. Helfand "Self Consistent Models for the X-ray Emission from Supernova Remnants: An Application to Kepler's Remnant" *Astrophys. J.* **291**, 544 (1985).

J.P. Caillault, D.J. Helfand, J. Nousek, and L. Takalo "X-ray Selected M-dwarfs and the Diffuse X-ray Background" *Astrophys. J.* **302**, 711 (1986).

Adair P. Lane, Anthony A. Stark, and David J. Helfand "G5.3+1.0: A Pressure-Confined Explosion in the Interstellar Medium" *Astrophys. J.* (submitted, 1986).

R.H. Becker, and D.J. Helfand "High Resolution Radio Observations of the SNR G24.7+0.6 and the Discovery of an Ultracompact HII Region" *Astrophys. J.* (in press, 1986).

D.J. Helfand and R.H. Becker "G0.9+0.1 and the Emerging CLass of Composite Supernova Remnants" *Astrophys. J.* (in press, 1986).

D.J. Helfand, G.A. Chanan, and H. Spinrad "The Extragalactic Nature of G227.141.0" *Nature* **320**, 41 (1986).

W.C. Erickson, M.J. Maloney, R.H. Becker, and D.J. Helfand "VLA Observations of the Fast Pulsar Candidate in M28" *Astrophys. J. Letters*, (in press, 1986).

Contributions in Conference Proceedings

D.J. Helfand, "X-ray Emission from Radio Pulsars: The Portable Supernova Remnants," in *Supernova Remnants & Their X-ray Emission*, J. Danzinger and P. Gorenstein (eds.), p. 471-486 (1983).

D.J. Helfand, "X-ray Synchrotron Nebulae and the Origin of Neutron Stars," *Adv. Space Res.* 3, pp 29-34 (1984).

D.J. Helfand "X-ray Surveys of the Magellanic Clouds" in *IAU Symposium Number 108, Structure and Evolution of the Magellanic Clouds*, S. van den Bergh and K.S. de Baer (eds.), pp 293-304 (1984).

David J. Helfand and R.H. Becker "Radio Observation of New and Used Crab-Like Supernova Remnants" in *The Crab Nebula and Related Supernova Remnants* M. Kafatos and R.B.C. Henry (eds.), Cambrige University Press, p. 241 (1985).

David J. Helfand "The Creation of Compact Objects in the Local Group" Proceedings of the JAPAN-US Seminar on "Compact Galactic and Extragalactic X-ray Sources", held in Tokyo, Japan, 16-18 January 1985.

David J. Helfand and R.H. Becker "The Progenitors and Products of Supernovae," Proceedings of the Advanced Study Institute on High Energy Phenomena Around Collapsed Stars, Reidel Publishing Co. (1986).

E. INTERACTIONS

Papers Presented at Scientific Meetings

Papers presented at the 159th Meeting of the AAS held in Boulder, Colorado, 10-13 January 1982:

- J.-P. Caillault, D.J. Helfand, and W.H.-M. Ku "An X-ray Survey of the Pleiades"

- D.J. Helfand "X-ray Synchrotron Nebulae and the Origin of Neutron Stars" (invited talk)

Paper presented at the Spring Meeting of the Astronomical Society of New York held in Rochester, New York, 16-17 April 1982:

-J.-P. Caillault, D.J. Helfand, and W.H.-M. Ku "An X-ray Survey of the Pleiades"

Papers presented at the 160th Meeting of the AAS held in Troy, New York, 6-9 June 1982:

- D.J. Helfand, G.A. Chanan, B. Margon, and R. Downes "Radio Emission from X-ray Selected AGN"

- D. Chance, R. Becker, and R. White "Radio Images of Eighteen Small Diameter Galactic Radio Sources"

Papers presented at the Fall Meeting of the Astronomical Society of New York held in Troy, New York, 31 October 1982:

- J. Hughes and D. Helfand "The Number-Diameter Relationship for Supernovae in the LMC"

- J.-P. Caillault, G.A. Chanan, D. Helfand, B. Margon, and R. Downes "The Contribution of M Stars to the Soft X-ray Background"

Papers presented at 161st Meeting of AAS held in Boston, Massachusetts, 9-12 January 1983:

- J.-P. Caillault, G.A. Chanan, and D.J. Helfand "The Contribution of M Stars to the Soft X-ray Background"

- J. Hughes, D.J. Helfand, K.S. Long, and R.L. White "Kepler's Supernova Remnant - Nonequilibrium Ionization Effects"

Paper presented at Spring Meeting of Astronomical Society of New York held in Ithaca, New York, May 13-14, 1983:

- T.T. Hamilton, R. Becker, and D.J. Helfand "A Search for Millisecond Pulsar Candidates in Globular Clusters"

- R. Pisarski, S. Kahn, and D. Helfand "An X-ray Study of the Remnant of SN 185 AD"

Papers presented at 162nd Meeting of AAS held in Minneapolis, Minnesota, 19-22 June 1983:

- J.P. Hughes and D.J. Helfand "The Number-Diameter Relationship for the Supernova Remnants"

- D.J. Helfand and R.H. Becker "The Observation of Stellar Remnants from Recent Supernovae"

Paper presented at COSPAR/IAU Symposium on Advances in High Energy Astrophysics and Cosmology held in Rojen, Bulgaria, 18-23 July 1983:

- David J. Helfand "X-ray Synchrotron Nebulae and the Origin of Neutron Stars"

Paper presented at the IAU Symposium Number 108, "Structure and Evolution of the Magellanic Clouds" held in Tubingen, Fed. Rep. of Germany, 5-8 September 1983.

- David J. Helfand "X-ray Surveys of the Magellanic Clouds"

Paper presented at the Fall Meeting of the Astronomical Society of New York, held at Union College, New York, 5 November 1983:

- J.-P. Caillault, G.A. Chanan, D.J. Helfand, J. Patterson, J. Nousek, L. Takalo, and G. Bothun, "The Peculiar X-ray Source AS431"

Papers presented at 163rd Meeting of AAS held in Las Vegas, Nevada, 8-11 January 1984:

- D.J. Helfand and R.H. Becker "Why are There So Few Composite SNR?"

- J.P. Hughes and D.J. Helfand "Nonequilibrium Ionization and the Supernova Remnants in the Large Magellanic Cloud"

- J.-P. Caillault, G.A. Chanan, D.J. Helfand, J. Patterson, J. Nousek, and L. Takalo "The Peculiar X-ray Source AS431"

Paper presented at the American Physical Society Meeting held in Washington, D.C. 23-26 April 1984.

- D.J. Helfand "Synchrotron Nebulae and the Origin of Neutron Stars" (invited review)

Paper presented at Spring Meeting of Astronomical Society of New York at Columbia University, New York, New York, 27 April 1984:

- D.J. Helfand, F.D. Seward, and F.R. Harnden "A New Crab-Like Pulsar in the Large Magellanic Cloud"

Papers presented at 164th meeting of AAS in Baltimore, Maryland, 10-13 June 1984.

- J.P. Hughes and D.J. Helfand "Kepler's Supernova Remnant - Self-Consistent Models for the X-ray Emission"

- J.-P. Caillault and D.J. Helfand "Further Analysis of the Pleiades X-ray Data"

Papers presented at the International Meeting on X-ray Astronomy held at Bologna, Italy, 26-30 June 1984:

D.J. Helfand and J-P. Caillault "An X-ray Survey of the Pleiades"

D.J. Helfand and J. Hughes "The Supernova Remnant Population of the Large Magellanic Cloud"

Paper presented at the Topical Meeting on X-ray Astronomy at the XXV Plenary Meeting of COSPAR held at Graz, Austria, 4 July 1984.

- D.J. Helfand "X-ray Observations of Composite Supernova Remnants"

Invited Review presented at the Workshop on International Cooperation in X-ray Astronomy at the XXV Plenary Meeting of COSPAR Held at Graz, Austria, 6 July 1984:

- D.J. Helfand "Galactic X-ray Astronomy"

Participation in Aspen Physics Center Workshop on "New Directions in Pulsar Physics" held at Aspen, Colorado, 6 August through 1 September 1984.

Papers presented at the Fall Meeting of the Astronomical Society of New York held in Schnectady, New York, November 3, 1984:

- David J. Helfand "The X-ray Source Populations of the Magellanic Clouds"

- J.-P. Caillault, G.A. Chanan, D.J. Helfand, J. Patterson, J. Nousek, L. Takalo, and G. Bothun "The Peculiar X-ray Source AS431"

Paper presented at the 165th Meeting of the AAS held in Tucson, Arizona, 14-16 January 1985:

- D.J. Helfand "Endpoints of Stellar Evolution: X-ray Surveys of the Local Group" (invited review)

Paper presented at the US/JAPAN Seminar "Compact X-ray Sources" held in Tokyo, Japan, 16-18 January 1985:

- D.J. Helfand "The Creation of Compact Objects in the Local Group" (invited review)

Paper presented at the 166th Meeting of the AAS in Charlottesville, Virginia, 4-7 June 1985

- D.J. Helfand and R.H. Becker "Accreting Binaries, Diffuse Radio Emission, and Galactic Cosmic Rays"

Paper presented at the Cargese Summer Institute on "High Energy Phenomena Around Collapse Stars" in Cargese, Corsica 2-13 September 1985

- D.J. Helfand "Supernova Remnants" (invited review)

Papers presented at the 168th Meeting of the AAS in Ames, Iowa, 22-26 June 1986

- D.J. Helfand and R.H. Becker "G0.9 and the Emerging Class of COMposite Supernova Remnants"

- S. Zoonematkermani, D.J. Helfand, and R.H. Becker "Crab-Like SNRs in M31"

F. PROFESSIONAL PERSONNEL

Principal Investigator:
David J.-Helfand, Associate Professor of Physics, Columbia University

Co-Investigators:

-.....1986 - none
-.....1985 - none
-.....1984 - none
- .1982-1983 - Gary A. Chanan, Assistant Professor of Physics
Columbia University
-...1982 - Robert H. Becker, Assistant Professor of Physics,
Virginia Polytechnic Institute and State University
(formerly, Research Associate, CAL, Columbia University)

Graduate Research Assistants:

-.....1985-1986 - Saied Zoonermatkermani
(Ph.D. to be awarded 6/88)
-.....1983-1986 - Thomas Hamilton
(Ph.D. to be awarded 6/87)
-.....1982-1985 - Jean-Pierre Caillault (PhD awarded 9/85)
-.....1982-1985 - Saeqa D. Vrtilek (PhD awarded 9/85)
-.....1983-1984 - John Hughes (PhD awarded 9/84)
-.....1982-1983 - Don Chance

Curriculum vita of the Principal Investigator may found in Appendix B.

APPENDIX A

Reprints from Papers Published

and Preprints of Papers Accepted for Publication

Under This Grant

1 October 1981 to 30 September 1986

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